

What is claimed is:

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1. A method of polarization measurement, comprising:
 - (a) directing an optical signal characterized by a polarization state into a polarization controller;
 - (b) directing the optical signal from the polarization controller into a polarizer;
 - (c) directing the optical signal from the polarizer to a wavelength dispersive element to generate a dispersed optical signal comprising a plurality of spectral components each characterized by a wavelength range;
 - (d) directing the dispersed optical signal into a photo-detector for detecting the plurality of spectral components;
 - (e) setting the polarization controller to a plurality of positions;
 - (f) for each of the plurality of positions of the polarization controller, measuring the power of the optical signal using the photo-detector; and
 - (g) obtaining the polarization state of the optical signal by analyzing the powers of the optical signal measured in (e).
 2. The method of claim 1, wherein the photo-detector is a photodiode array comprising a plurality of detector pixels.
 3. The method of claim 2, wherein at least a subset of the plurality of detector pixels each detects only a portion of the dispersed optical signal having a Stokes vector that remains substantially constant within each of the detector pixels in the subset of detector pixels.

4. The method of claim 3, wherein (e) comprises setting the polarization controller to at least four different positions.
- 5 5. The method of claim 4, wherein (g) further comprises:
(g1) generating an optical power parameter for each of the subset of the plurality of detector pixels;
(g2) analyzing the optical power parameters and the corresponding wavelength ranges detected by the subset of
10 the plurality of detector pixels; and
(g3) calculating Stokes components for the optical signal to obtain the polarization state of the optical signal.
- 15 6. The method of claim 5, further comprising:
(h) calculating an optical power for the optical signal.
7. The method of claim 6, wherein the optical signal is a
20 data signal in a wavelength division multiplexed (WDM) system and one or more of the plurality of spectral components in the dispersed optical signal correspond to a plurality of WDM optical channels.
- 25 8. The method of claim 1, wherein:
the polarization controller consists of a half-wave plate followed by a quarter-wave plate each characterized by respective orientations;
(e) comprises setting the polarization controller to
30 at least four different positions; wherein
the first of the at least four different positions corresponds to setting the half-wave plate orientation and the quarter-wave plate orientation to be same as an orientation of the polarizer;

the second of the at least four different positions corresponds to setting the half-wave plate orientation at about 22.5 angular degrees with respect to the orientation of the polarizer, and setting the quarter-wave plate orientation to be same as the orientation of the polarizer;

the third of the at least four different positions corresponds to setting the half-wave plate orientation at about 45 angular degrees with respect to the orientation of the polarizer, and setting the quarter-wave plate orientation to be same as the orientation of the polarizer; and

the fourth of the at least four different positions corresponds to setting the half-wave plate orientation at about 22.5 angular degrees and the quarter-wave plate orientation at about 45 angular degrees with respect to the orientation of the polarizer.

9. The method of claim 1, wherein the polarization controller is a quarter-wave plate, and (e) comprises rotating the quarter-wave plate continuously as a function of time.

10. The method of claim 1, wherein one or more of the plurality of spectral components has a corresponding Stokes vector that varies within the respective wavelength range.

11. A method of optical measurements, comprising:
(a) directing the optical signal characterized by a polarization state into a polarization controller;
(b) directing the optical signal from the polarization controller into a polarizer;
(c) directing the optical signal from the polarizer to a wavelength dispersive element to generate a dispersed

optical signal comprising a plurality of spectral components each characterized by a wavelength range;

(d) directing the dispersed optical signal into a photo-detector for detecting the plurality of spectral components;

(e) setting the polarization controller to a plurality of positions;

(f) for each of the plurality of positions of the polarization controller, measuring the power of the dispersed optical signal using the photo-detector; and

(g) obtaining at least one desired property of the optical signal by analyzing the measured powers of the dispersed optical signal.

12. The method of claim 11, wherein the plurality of positions in (e) is at least two.

13. The method of claim 12, wherein the at least one desired property in (g) is a spectral power density of the optical signal.

14. The method of claim 11, wherein the plurality of positions in (e) is at least four, and the at least one desired property in (g) are the polarization state and an optical power of the optical signal.

15. A method of monitoring degree of polarization of an optical signal, comprising:

(a) directing the optical signal into a polarization controller;

(b) directing the optical signal from the polarization controller into a polarizer;

(c) directing the optical signal from the polarizer to a wavelength dispersive element to generate a dispersed

optical signal comprising a plurality of spectral components;

(d) directing the dispersed optical signal into a photo-diode array comprising a plurality of detector

5 pixels for detecting the plurality of spectral components;

(e) setting the polarization controller to a plurality of positions;

(f) for each of the plurality of positions of the polarization controller, measuring an optical power

10 detected by each of the plurality of detector pixels; and

(g) obtaining the degree of polarization of the optical signal by analyzing the optical powers measured in (e).

15 16. The method of claim 15, wherein the optical signal is a data signal in a wavelength division multiplexed (WDM) system characterized by a plurality of WDM channels.

20 17. The method of claim 16, wherein each of the plurality of WDM channels is detected by a different subset of the plurality of detector pixels.

25 18. The method of claim 17, wherein (g) further comprises calculating Stokes components corresponding to each of the plurality of WDM channels to obtain the degree of polarization for each of the plurality of WDM channels.

30 19. An apparatus for polarization measurement, comprising:
a polarization controller for receiving an optical signal;

a polarizer for receiving the optical signal exiting the polarization controller;

35 a wavelength dispersive element for separating the optical signal exiting the polarizer into a plurality of spectral components; and

a photo-detector for detecting the plurality of spectral components.

20. The apparatus of claim 19, wherein the wavelength
5 dispersive element is a grating.

21. The apparatus of claim 19, wherein the photo-detector
is a photodiode array.

10 22. The apparatus of claim 19, wherein the polarization
controller is an electro-optic device.

15 23. The apparatus of claim 22, wherein the electro-optic
device is fabricated from lithium niobate.

24. The apparatus of claim 19, wherein the wavelength
dispersive element has an optical resolution at least
sufficient to resolve adjacent signal channels in a
wavelength division multiplexed communication system.

20 25. A method of determining a polarization mode dispersion
in a transmission system, comprising:

(a) propagating a data signal characterized by a
wavelength range through an optical fiber in the
25 transmission system; and

(b) determining the polarization mode dispersion in
the optical fiber concurrent with (a) by:

(b1) directing a portion of the data signal into a
polarization analyzer;

30 (b2) measuring optical powers for the portion of
the data signal as a function of wavelength within the
wavelength range; and

(b3) generating polarization parameters from the
optical powers measured in (b2).

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26. The method of claim 25, further comprises:

(c) prior to (a), directing the data signal through a polarization switch.

5 27. The method of claim 26, wherein (b2) is performed for two different and non-orthogonal polarization states of the data signal generated by the polarization switch.

10 28. The method of claim 27, wherein the polarization analyzer comprises a polarization controller, a polarizer, a wavelength dispersive element and a photo-detector.

29. The method of claim 28, wherein (b1) further comprises:

15 (i) directing the portion of the data signal into the polarization controller;

(ii) directing the portion of the data signal from the polarization controller into the polarizer;

20 (iii) generating a plurality of spectral components by directing the portion of the data signal from the polarizer onto the wavelength dispersive element; and

(iv) directing the plurality of spectral components into the photo-detector; wherein the photo-detector is a photo-detector array.

25 30. The method of claim 29, wherein the transmission system is a wavelength division multiplexing (WDM) system, and the data signal comprises a plurality of wavelengths corresponding to a plurality of optical channels in the
30 WDM transmission system.

31. The method of claim 30, further comprising:

in (b1), generating sequentially at least four different polarization states for the data signal by

adjusting the polarization controller of the polarization analyzer; and

in (b2), measuring respective optical powers for each of the plurality of optical channels for each of the at least four different polarization states generated sequentially in (b1).

32. A method of monitoring polarization mode dispersion (PMD) in an optical fiber, comprising:

10 (a) propagating a wavelength division multiplexed (WDM) optical signal comprising a plurality of WDM channels through the optical fiber;

(b) directing the WDM optical signal into a PMD compensator;

15 (c) determining a degree of polarization for each of the plurality of WDM channels by:

(c1) directing a first portion of the WDM optical signal from the PMD compensator into a polarization analyzer comprising a polarization controller, a polarizer, a wavelength dispersive element and a photo-detector array; wherein after the first portion of the WDM optical signal propagates through the polarization controller and the polarizer, the wavelength dispersive element disperses the first portion of the WDM optical signal into a plurality of spectral components corresponding to the plurality of WDM channels; and the photo-detector array detects the plurality of spectral components;

20 (c2) calculating Stokes parameters for each of the plurality of WDM channels by measuring an optical power with the photo-detector array for each of the plurality of WDM channels;

25 (c3) obtaining the degree of polarization from the Stokes parameters for each of the plurality of WDM channels;

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(d) deriving PMD information for the WDM optical signal from the degree of polarization for each of the plurality of WDM signal channels;

(e) using the PMD information for the WDM optical signal for controlling the PMD compensator; and

(f) directing a second portion of the WDM optical signal from the PMD compensator into a WDM receiver unit.

33. An apparatus for determination of polarization mode dispersion in an optical fiber, comprising:

a polarization switch connected to an input of the optical fiber characterized by a polarization mode dispersion; and

a polarization analyzer connected to an output of the optical fiber, wherein the polarization analyzer comprises a polarization controller, a polarizer, a wavelength dispersive element and a photo-detector.

34. The apparatus of claim 33, wherein the wavelength dispersive element is a diffraction grating.

35. The apparatus of claim 34, wherein the photo-detector is a photodiode array.

36. The apparatus of claim 35, wherein the polarization controller is an electro-optic device.

37. The apparatus of claim 36, wherein the electro-optic device is fabricated from lithium niobate.

38. A wavelength division multiplexed (WDM) communication system, comprising:

(a) a plurality of transmitters for generating a plurality of optical signals corresponding to a plurality of optical channels in the WDM communication system;

(b) a multiplexer for combining the plurality of optical signals into a multiplexed optical signal;

(c) a polarization switch connected to an output of the multiplexer;

5 (d) a transmission fiber connected to an output of the polarization switch for transmitting the multiplexed optical signal, wherein the transmission fiber is characterized by a polarization mode dispersion (PMD);

10 (e) a polarization analyzer for receiving a first portion of the multiplexed optical signal transmitted through the transmission fiber, wherein the polarization analyzer comprises a polarization controller, a polarizer, a wavelength dispersive element and a photo-detector array;

15 (f) a controller for generating a control signal responsive to a signal received from the polarization analyzer;

20 (g) a PMD compensator responsive to the control signal, for converting a second portion of the multiplexed optical signal transmitted through the transmission fiber into a PMD-compensated multiplexed optical signal;

(h) a demultiplexer connected to an output of the PMD compensator for decomposing the PMD-compensated multiplexed optical signal into a plurality of transmitted
25 optical signals corresponding to the plurality of channels in the WDM system;

(i) a plurality of receivers for detecting the plurality of transmitted optical signals.